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Modeling Compressive Strength Effect of High-Volume Fly Ash Partially Replaced Cement and Sand with Glass Fiber on Concrete Durability

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ABSTRACT

Fly ash known to be by product and less expensive compared to Portland cement, the byproduct are known to improve workability and reduce the internal temperature, the advantage of these product is that it increase the workability to generates the required compressive strength, another quality is that it improves the grading in the mixture by smoothing out the fine particle size distribution, it also decrease the amount of water required, the present of fly in concrete definitely creates and additional C-S-H gel compared to that of normal concrete, this is because of additional creation on C-S-H gel in the microstructure of mix that it enhanced to improved the compressive strength. The study examined when cement replacement at 40% by fly ash [F40-0], the compressive strength experienced decrease compared to that of concrete made with glass fiber, but sand replaced 20% percent of fly ash [F20-0],its compressive strength experienced an increase in the concrete model compared to that of concrete made with fiber glass at 28% days. fly ash primary is to credit the ball bearing property, because of it round shape of fly ash particles, these spherical shape affect fly ash particles thus decrease the internal friction in fresh concrete, and improve the flowability of fresh concrete, the condition of glass fiber experiencing decrease are known to be adjusted by the incorporation of fly ash in concrete to maintained increase in strength development. The study from the simulation results observed that partial replacement of cement at 20% [F20-0] and 40% [F40-0] by fly ash experienced reduction on it values based on shrinkage, this also include other parameters such as 20% [F20-0] and 40%[F40-0] that also experienced decrease, the simulation values was in agreement with (Raut, and Deo, 2019).The fiber in the study for compressive strength arrest crack in concrete which improve the strain harden property thus increase compressive strength. The application of 20%cement replacement with fiber glass and fly ash observed an improvement in strength development compared to the normal strength, similar condition was observed as an increase in the curing age of 119 days .The predictive were validated with (Raut, and Deo 2019) and both parameters for compressive strength developed best fits correlation.

Keywords: *Modeling, High Volume, Fly Ash, Cement, Glass fiber, and Concrete durability*

INTRODUCTION

In most nations like India, the generation of electricity mostly rely on coal-based power plant, this generates more than 184 million tons of fly ash per year, and half of it is applied[1].Mean-while, the generate of cement enhance rapidly globally, total emission from cement industry add to the extent that 8% of worldwide CO2 emission [2]. The Durability is the most important properties of concrete to one side from its strength.

Studies have made tremendous improvement on the strength and durability by adding fibers thus the by-product from industries such as fly ash in concrete. Meanwhile, several researchers has carried out studies on concrete containing high volume fly ash, this has reported exhibiting tremendous durability properties such as high strength and low shrinkage [4]. Most of this Authors has reported the heterogeneities in the numerous researchers observe that the addition of high-volume fly ash in the matrix improvement the electrical resistivity. The authors also try to investigate the addition of 50% fly ash as a cement replacement improvement of the electrical resistivity of 4.8 times compared to normal concrete [8]. Studies from experts finds out by the addition of 60% fly ash as a cement replacement the improvement in electrical resistivity observed at 9.1% compared to the normal concrete [9]. Furthermore, Microstructure of the hydrated Portland cement paste, particularly the existence of huge pores and bulky crystalline products in the switch zone, were greatly decrease by the introduction of fine particles of fly ash [5]. Comprehensive researchers concluded that the replacement of cement high volume fly ash decreases the chloride penetration of concrete specimens [6, 7, 8, 9]. Several experts conclude that the addition of different kinds of fiber offer better performance of the concrete, while the mixture of fly ash fly may adjust the loss of concrete workability, because of an addition of fibers that has improve the strength of concrete [11, 12, 14]. An examination carried out that showed the compressive strength, split tensile strength and flexural strength of fly ash concrete mixes ranged from 10% to 50% fine aggregate replacement by fly ash, observed to be higher than control mix at all ages [1317,18.19]. It has also been reported that by replacement of 15% sand with fly ash by weight, there is an improvement of compressive strength by about 30% [14,15,16 and 17]. The most significant finding by the expert is on the influence of high volume fly ash as a partly sand replacement in fiber reinforced concrete, it also showed that the compressive and tensile strength values achieved double strength development compared to those of concrete without fly ash [15, 20, 21,22,23,24 and 25].

THEORETICAL BACKGROUND

$$\frac{dc_d}{dx} + V(y)c_d = \Phi(y)c_d^n \qquad (1.0)$$

Dividing equation (1.0) all through by c_d^n,we have

$$c_d^{-n}\frac{dc_d}{dx} + v(x)c_d^{1-n} = \Phi(y) \qquad (1.1)$$

Let

$$P = c_d^{1-n} \qquad (1.2)$$

$$\frac{dp}{dy} = (1-n)c_d^{-n}\frac{dc_d}{dy}$$

$$c_d^{-n}\frac{dc_d}{dy} = \frac{1}{1-n}\frac{dp}{dy} \qquad (1.3)$$

Substituting equation (1.2) and (1.3) into equation (1.1) we have that

$$\frac{1}{1-n}\frac{dp}{dx} + V(y)p = \Phi(y) \qquad (1.4)$$

Integrating both sides we have

$$\int d\left[e^{V(y)(1-n)y}p\right] = \Phi(y)(1-n)\int e^{V(y)(1-n)y}dy$$

$$p = \frac{\Phi(y)}{Vu(y)} + Ae^{-Vu(y)(1-n)y} \qquad (1.5)$$

Substituting equation (1.2) into equation (1.13) we have

$$c_d^{1-n} = \frac{\Phi(y)}{Vu(y)} + Ae^{-Vu(y)(1-n)y} \qquad (1.6)$$

MATERIALS AND METHOD

Experimental Procedures

Compressive Strength Test Concrete cubes of size 150mm×150mm×150mm were cast with and without copper slag. During casting, the cubes were mechanically vibrated using a table vibrator. After 24 hours, the specimens were demoulded and subjected to curing for 1-90 days and seven-day interval to 28 days in portable water. After curing, the specimens were tested for compressive strength using compression testing machine of 2000KN capacity. The maximum load at failure was taken. The average compressive strength of concrete and mortar specimens was calculated by using the following equation

Compressive strength (N/mm2) = Ultimate compressive load (N)

Area of cross section of specimen (mm2)

RESULTS AND DISCUSSION

Table1. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.35 [C0-0]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [C0-0]
7	32.55526374	32
28	41.62264191	40
56	48.25305332	48
119	52.67961232	52

Table2. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.35 [F0-0]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [F0-0]
7	42.10766414	42
28	48.8050369	48
56	56.05426619	55
119	59.67953798	59

Table3. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.45 [F20-0]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [F20-0]
7	45.61134142	45
28	56.02771946	55
56	64.49687131	65
119	71.93275087	72

Table4. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.35 [F40-0]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [F40-0]
7	39.65030522	38
28	44.35688348	45
56	55.69948609	55
119	57.93995068	58

Table5. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.35 [F20-20]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [F20-20]
7	53.78053127	54
28	65.40230762	64
56	73.17077634	72
119	76.7304522	75

Table6. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.35 [F40-20]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [F40-20]
7	44.64662668	44
28	51.01477926	52
56	61.29865952	61
119	62.0329751	63

Table7. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.35 [F20-40]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [F20-40]
7	42.00061191	42
28	48.9957374	48
56	57.82738833	56
119	59.28764687	58

Table8.*Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.35 [F40-40]	Experimental Values of Compressive Strength Variation of [W/C of 0.35 [F40-40]
7	32.38155902	31
28	38.19383687	38
56	49.27116689	48
119	49.64535144	50

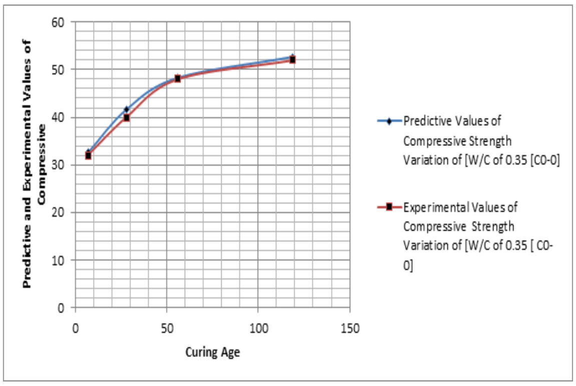

Figure1. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

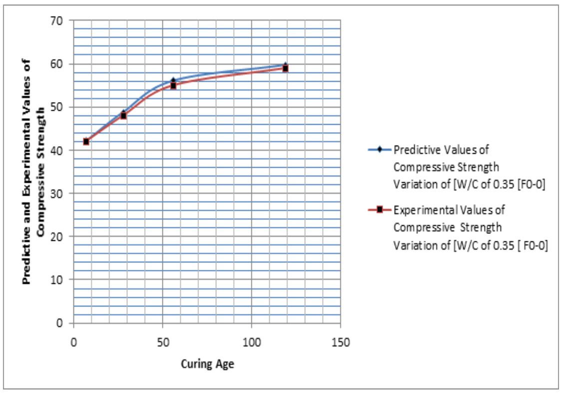

Figure2. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

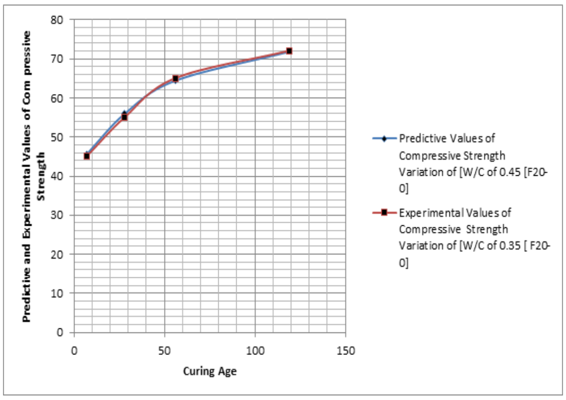

Figure3. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

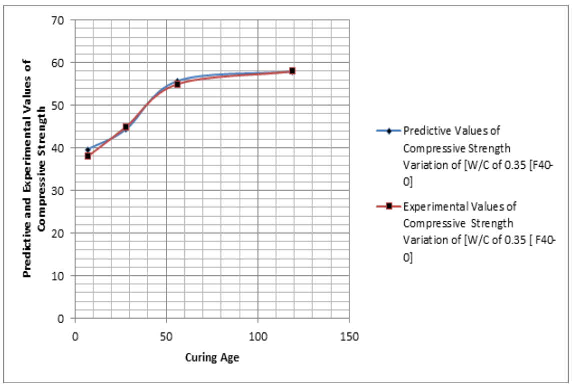

Figure4. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

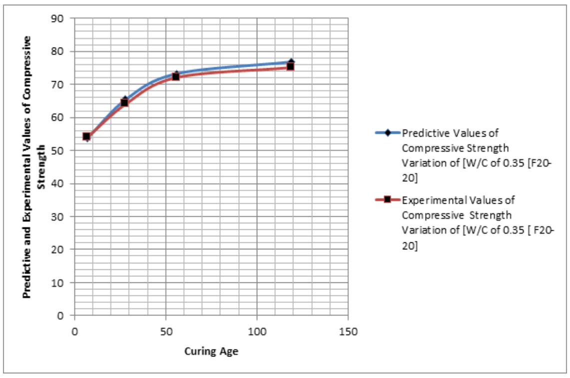

Figure5. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

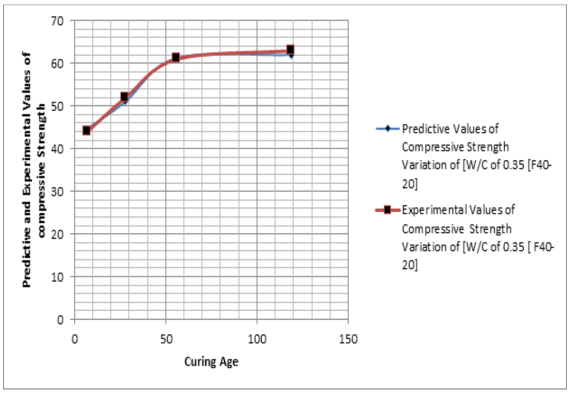

Figure6. *Predictive and Experimental Value of Compressive Strength at Different Curing Age*

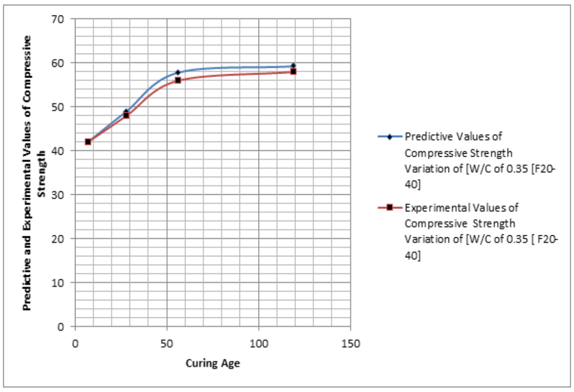

Figure7.*Predictive and Experimental Value of Compressive Strength at Different Curing Age*

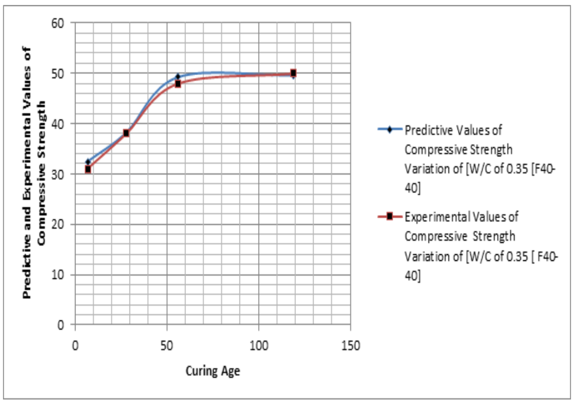

Figure8.*Predictive and Experimental Value of Compressive Strength at Different Curing Age*

Figure 1-8 explained the rapid growth within 7 and 14 days and maintained constant increase within 14-28 days, the rate of increase are determined on the mixed design applied, it is reflected on the dosage of the addictive that partially replace cement, such Volume of fly ash partially replaced cement and sand with glass fiber on concrete durability, it has expressed its behaviour on the concrete formation to generate variation of compressive strength. The effects on the compressive strength were monitored at different percentage of high-volume fly ash in the designed concrete model, the application of high-volume fly ash where the replacements are within fifty to sixty percent in some mixed designed that are observed. But in mixed proportion, it is usually in concrete that it replacement range from 0-30 percent by mass, the developed mix proportion generate the designed mixed with glass fiber and without glass fiber, there was variation of results as it is observed from the figures, the designed mix with water cement ratio of 0.35 influenced by fly ash are based on its workability of concrete to generate compressive strength. It was calibrated in terms of slump in the simulation, it was observed that concrete with glass fiber without any partial replacement experienced decrease in workability as the addiction of fiber in concrete inhibit the flowability of the mix, the simulation observed in the dosage from 10%, 20%,30%, and 40% of fly ash developed an increase in slump, while the increase in fly ash generate increase in workability, thus developed the required compressive strength, the fly ash primary credited the ball bearing property, because of it round shape of fly ash particles, these spherical shape affect fly ash particles thus decrease the internal friction in fresh concrete, it also improve the flowability of fresh concrete, the condition of glass fiber experiencing decrease can be adjusted by the incorporation of fly ash in concrete to maintained increase in strength development. The study from the simulation results observed that partial replacement of cement at 20% [F20-0] and 40% [F40-0] by fly ash also experienced reduction on its values based on shrinkage, this also include other parameters such as 20% [F20-0] and 40%[F40-0] that also experienced decrease, the simulation values was in agreement with (Raut, and Deo 2019). The fiber in the study for compressive strength arrest crack in concrete which improve the strain harden property thus increase compressive strength. The application of 20% cement replacement with fiber glass and fly ash observed an improvement in strength development compared to the normal strength, similar condition was observed as an increase in the curing age of 119 days .The predictive were validated with (Raut, and Deo 2019) and both parameters for compressive strength developed best fits correlation.

CONCLUSION

The study expresses the behaviour of these materials, The effects on the compressive strength were monitored at different percentage of high volume of fly ash in the designed concrete model, the application of high volume of fly ash where the replacements are within fifty to sixty percent in some mixed designed were observed and compared. the simulation observed in the dosage from 20%,30%, and 40% of fly ash and it developed an increase in slump, it also improve the flowability of fresh concrete, the condition of glass fiber experiencing decrease that are adjusted by the incorporation of fly ash in concrete to maintained increase in strength development. The study from the simulation results observed that partial replacement of cement at 20% [F20-0] and 40% [F40-0] by fly ash experienced reduction on it values based on shrinkage. this also include other parameters such as 20% [F20-0] and 40% [F40-0] that also experienced decrease, the simulation values was in agreement with (Raut, and Deo 2019).

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